Using multiple space assets with In-situ measurements
to track flooding in Thailand

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Abstract—Increasing numbers of space assets can enable coordinated measurements of flooding phenomena to enhance tracking of extreme events. We describe the use of space and ground measurements to target further measurements as part of a flood monitoring system in Thailand. We utilize rapidly delivered MODIS data to detect major areas of flooding and the target the Earth Observing One Advanced Land Imager sensor to acquire higher spatial resolution data. Automatic surface water extent mapping products delivered to interested parties. We are also working to extend our network to include in-situ sensing networks and additional space assets.

Keywords: sensorwebs, flooding, hydrology, natural disasters, onboard processing.

I. INTRODUCTION

Flooding has a tremendous impact in humanitarian and economic ($$) terms worldwide. Recent flooding in Thailand October-November 2010 [MCOT 2010, Bangkok Post 13 Nov 2010, Wikipedia 2010] was responsible for over 200 deaths, over $1.67 Billion USD damage, and affected over 7 million people [CNN 2010].

Flooding has a tremendous impact on humanity. From p. 348, [NRC 2007] "Floods are among the most destructive of natural disasters. From a monetary standpoint, flood damages in the United States averaged around $5 billion per year in the 1990s in 1995 dollars (Table 3.1 in Pielke et al., 2002). Outside the United States, the impact is even more striking; flood losses globally increased 10-fold (inflation-corrected) over the second half of the 20th century to a total of around $300 billion in the decade of the 1990s (Kabat and van Schaik, 2003)."

Flooding is also a key part of the global hydrologic cycle. "The scientific challenge posed by the need to observe the global water cycle is to integrate in situ and space-borne observations to quantify the key water-cycle state variables and fluxes." [NRC, 2007]).
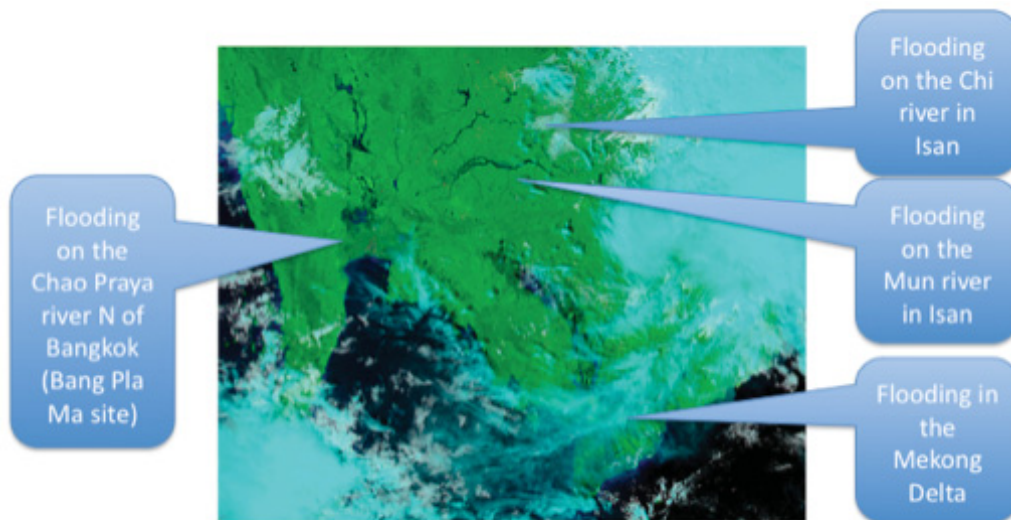

Figure 1: Aqua/MODIS 28 Nov 2010 Imagery of Thailand Flooding (band 7-2-1)
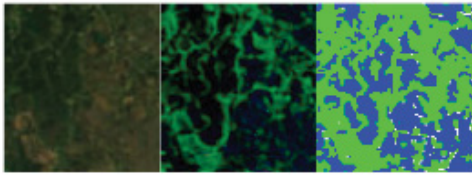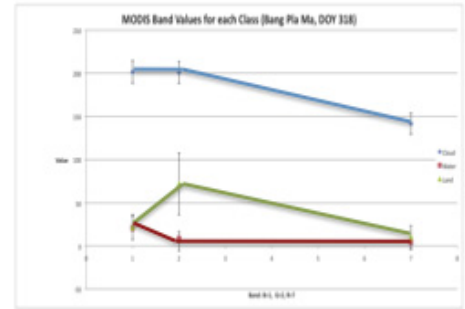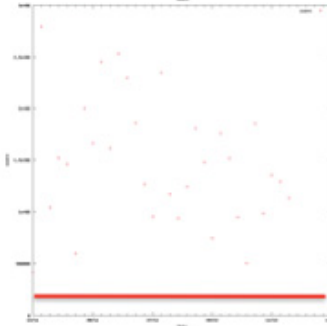
Figure 2a: True color, band 7-2-1, and flood classified MODIS imagery from 5 Nov 2010 of Bang Pla Ma Site
Figure 2b: Flood score for same site, 150,000 score threshold marked, dry baseline score is 5000.
Figure 2c: average and std. dev. spectra for each class

This paper describes an effort to integrate space-borne sensing from MODIS (Terra and Aqua), ALI (EO-1), Worldview-2, and in-situ sensing, with hydrological models to improve flood monitoring in Thailand.

II. FLOOD DETECTION USING MODIS

Prior significant efforts have utilized MODIS to monitor flooding worldwide [Brakenridge 2005, Carroll et al. 2009]. However MODIS can only offer low spatial resolution (250m-1000m/pixel) and is often hampered by cloud cover. Higher spatial resolution sensors and radar can often supplement the outstanding spatial coverage and temporal resolution of MODIS. Additionally, in-situ sensors can provide reliable point sampling of the flooding phenomena. All of these data can then be combined with hydrological models to perform hindcasting, nowcasting, and forecasting of flooding for use by relevant authorities.

MODIS sensing provides excellent temporal coverage (2x per day daylight overflights), spectral range (0.62-14.3 µ), and spatial coverage (coverage of the majority of Thailand each overflight). We draw the subsetted FAS Indochina MODIS data as geotiff from the site http://rapidfire.sci.gsfc.nasa.gov/ and utilize the band 7-2-1 combination to feed both threshold and Support Vector

methods to classify scenes into: water, land, and clouds. We are currently tracking a number of sites on the Chao Praya River in western Thailand North of Bangkok as well as eight (8) sites along the Chi river in northeastern Thailand. For each test site we examine a 20 x 20 km area and compare the current flooded extent by counting flood classified pixels and examining prior pixels up to 3 days prior to address cloud cover occlusions. For each test site, the flood score is compared to a baseline score from the dry season. If the current flood score exceeds the baseline by a manually tuned threshold a flood alert is issued for the site. Figure 1 shows MODIS band 7-2-1 showing the extreme flooding in the Chao Praya, Chi, and Mun river basins in Thailand as well as the Mekong Delta in Vietnam in the Fall of 2010. Figure 2 shows the true color, band 7-2-1, surface water extent maps, and flooding scores (flooded and dry) for the Bang Pla Ma area NW of Bangkok near the Chao Praya river. The flood classification score for the October – December 2010 timeframe ranges from 500,000+ easily distinguishable from the dry season baseline score of 5000.

III. AUTOMATED RESPONSE IMAGERY USING THE ADVANCED LAND IMAGER ON EARTH OBSERVING ONE

The Earth Observing One spacecraft has automated tasking capability [Chien 2005] and is integrated with this alert system to automatically task to image flooded areas using the Advanced Land Imager (ALI) Instrument (30km wide swath, 30m spatial resolution multispectral, 9 bands 0.4-2.4 µ spectral range). This imagery is automatically processed to derive surface water extent maps using both SVM and ratio (0.55/0.86 µ) threshold methods [Ip et al. 2006]. Figure 3a shows ALI imagery and associated SVM and band ratio surface water extent maps for the Ayutthaya-Chao-Praya Site acquired 03 December 2010. Figure 3b shows the mean and standard deviation of spectra from each of the band ratio classified portions of the image showing the separation between the flooded and non-flooded areas of the image.

We have also been investigating the possibility of bringing in other satellites including Digital Globe's Worldview-2. Worldview-2 offers 1.5m spatial resolution 8 band 0.4-1.05 µ multispectral imagery. Figure
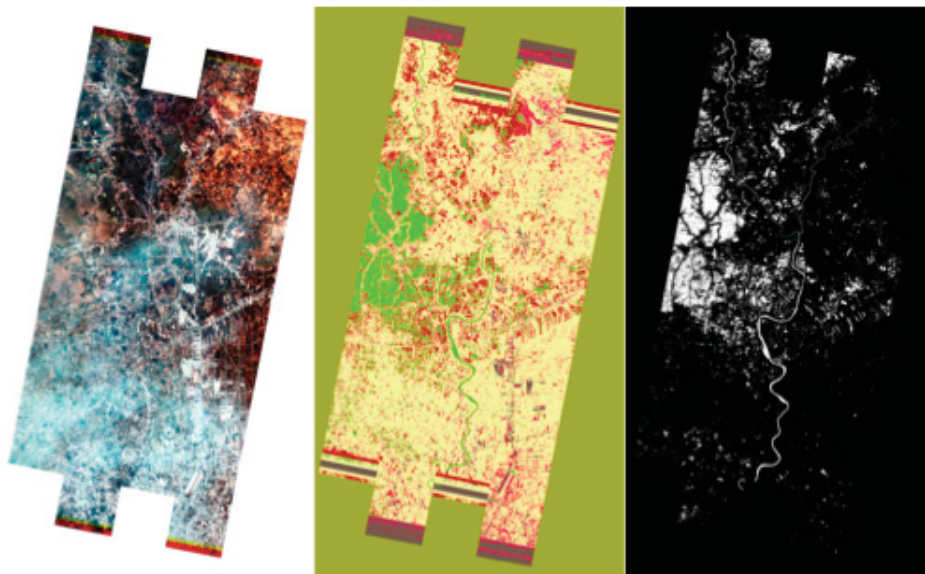

Figure 3a: ALI Imagery – Color, SVM classified flood, and band ratio classified flood for Ayutthaya-Chao-Praya Site acquired 03 December 2010
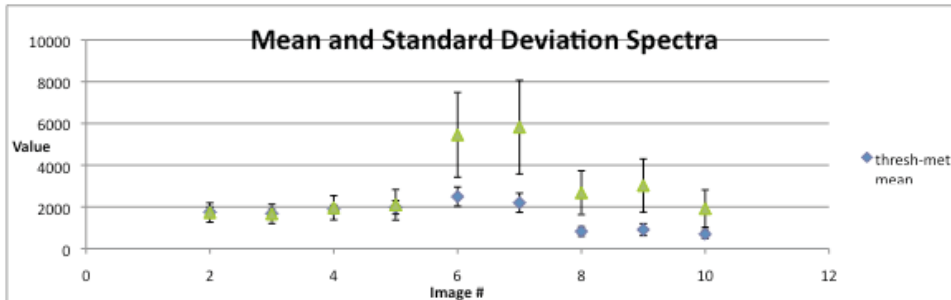
Figure 3b: Spectral signatures for water and other classes for band ratio classified image for Ayutthaya-Chao-Praya Site 03 Dec 2010

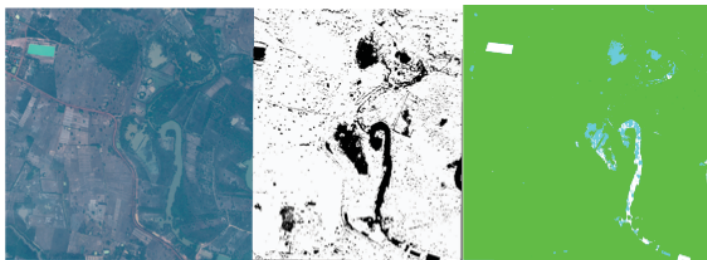Figure 4: Automated Classification of Worldview-2 Imagery

Figure 4a:
Isan Color Scene (L)
Band ratio surface water extent classification map (C)
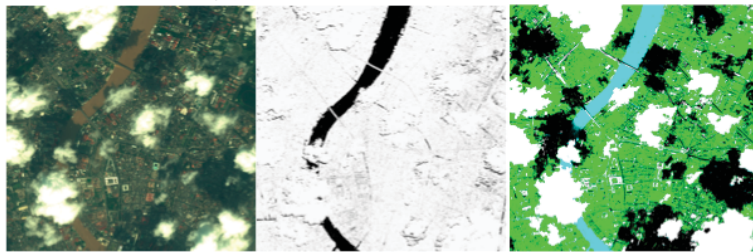SVM classification map (R)

Figure 4b:
Downtown Bangkok Color Scene (L)
Ratio classification map (C)
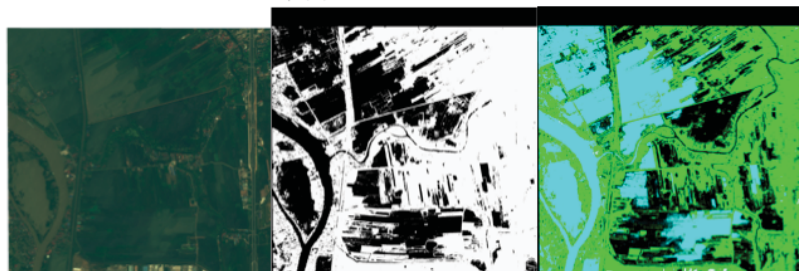SVM Classification Map (R)

Figure 4c:
Ayatthaya Color Scene (L)
Band ratio classification map (C)
SVM classification map (R)

4a-c shows color and surface water extent maps and sample spectra for WV-2 imagery derived for test sites on the Chao Praya and Eastern Thailand using both the ALI ratio method and SVM classification. Figure 4d shows sample spectra from these same images.

Additionally, we are investigating the potential use of Landsat-5 Thematic Mapper data which is automatically acquired and downlinked via Thai groundstations.

IV. INTEGRATION OF IN-SITU SENSING NETWORKS , DATA DELIVERY, AND HYDROLOGICAL MODELLING

We are also working to integrate available in-situ data. Thailand's Hydro Agro Informatics Institute (HAII) processes data from over 200 in-situ stations including numerous rainfall, water level, and flow rate sensors (e.g. for the Mun river basin see http://www.thaiwater.net/DATA/REPORT/php/mun_scada/mun_scada.php). Additionally, Khon Kaen University is in the process of developing and deploying further in-situ sensors to the Huay Sa Batt and Chi river basins.

We currently are developing mechanisms to automatically deliver the satellite data and in-situ sensor data to drive hydrological models to provide data for decision support in flood response. Currently the satellite data and products are provided over the internet to interested parties.

V. CONCLUSIONS

We have described a networking of sensors to improve tracking of flooding in Thailand. We describe an approach to large-scale flood detection using broad swath moderate resolution MODIS data that then enables automated targeting of higher resolution sensors such as EO-1/ALI. We have also described methods for deriving surface water extent products from MODIS, ALI, and Worldview-2 data. We are currently working to integrate in-situ data into this system and to enable automatic ingestion of this information into hydrological models of the relevant river basins.

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Figure 4d: WV-2 Sample Spectra

Sample Water Spectra

Sample Land Spectra

Sample Cloud Spectra